

## LM140K 3-Terminal Positive Regulator

Check for Samples: [LM140K](#)

### FEATURES

- Complete Specifications at 1A Load
- Output Voltage Tolerances of  $\pm 4\%$  at  $T_j = 25^\circ\text{C}$
- Internal Thermal Overload Protection
- Internal Short-circuit Current Limit
- Output Transistor Safe Area Protection
- P<sup>+</sup> Product Enhancement Tested

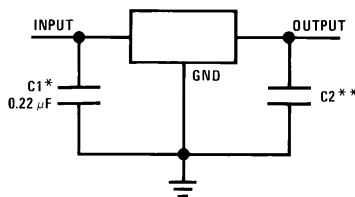
### DESCRIPTION

The LM140K monolithic 3-terminal positive voltage regulator employs internal current-limiting, thermal shutdown and safe-area compensation, making them essentially indestructible. If adequate heat sinking is provided, they can deliver over 1.0A output current. They are intended as fixed voltage regulators in a wide range of applications including local (on-card) regulation for elimination of noise and distribution problems associated with single-point regulation. In addition to use as fixed voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents.

Considerable effort was expended to make the entire series of regulators easy to use and minimize the number of external components. It is not necessary to bypass the output, although this does improve transient response. Input bypassing is needed only if the regulator is located far from the filter capacitor of the power supply.

The LM140K is available in 5V, 12V and 15V options in the steel TO-3 power package.

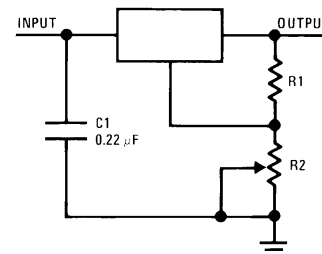
### Typical Applications



\*Required if the regulator is located far from the power supply filter.

\*\*Although no output capacitor is needed for stability, it does help transient response. (If needed, use 0.1  $\mu\text{F}$ , ceramic disc).

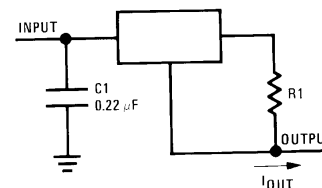
**Figure 1. Fixed Output Regulator**



$$V_{OUT} = 5V + (5V/R1 + I_Q) R2 \quad R2 \geq 5V/R1 > 3 I_Q$$

load regulation ( $L_r$ )  $\approx [(R1 + R2)/R1]$  ( $L_r$  of LM140K-5.0).

**Figure 2. Adjustable Output Regulator**



$$I_{OUT} = \frac{V_{2-3}}{R1} + I_Q$$

$$\Delta I_Q = 1.3 \text{ mA over line and load changes.}$$

**Figure 3. Current Regulator**

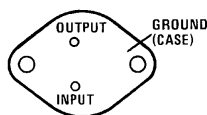


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PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of the Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

## Connection Diagrams



**Figure 4. TO-3 Metal Can (Bottom View)**



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## Absolute Maximum Ratings<sup>(1)(2)(3)</sup>

DC Input Voltage		35V
Internal Power Dissipation <sup>(4)</sup>		Internally Limited
Maximum Junction Temperature		150°C
Storage Temperature Range		–65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	TO-3 Package (NDS)	300°C
ESD Susceptibility <sup>(5)</sup>		2 kV

- (1) Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Conditions are conditions under which the device functions but the specifications might not be ensured. For ensured specifications and test conditions see the Electrical Characteristics.
- (2) Specifications and availability for military grade LM140H/883 and LM140K/883 can be found in the LM140QML datasheet (SNVS382). Specifications and availability for military and space grade LM140H/JAN and LM140K/JAN can be found in the LM140JAN datasheet (SNVS399).
- (3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
- (4) The maximum allowable power dissipation at any ambient temperature is a function of the maximum junction temperature for operation ( $T_{JMAX} = 125^{\circ}\text{C}$  or  $150^{\circ}\text{C}$ ), the junction-to-ambient thermal resistance ( $\theta_{JA}$ ), and the ambient temperature ( $T_A$ ).  $P_{DMAX} = (T_{JMAX} - T_A)/\theta_{JA}$ . If this dissipation is exceeded, the die temperature will rise above  $T_{JMAX}$  and the electrical specifications do not apply. If the die temperature rises above  $150^{\circ}\text{C}$ , the device will go into thermal shutdown. For the TO-3 package (NDS), the junction-to-ambient thermal resistance ( $\theta_{JA}$ ) is  $39^{\circ}\text{C/W}$ . When using a heatsink,  $\theta_{JA}$  is the sum of the  $4^{\circ}\text{C/W}$  junction-to-case thermal resistance ( $\theta_{JC}$ ) of the TO-3 package and the case-to-ambient thermal resistance of the heatsink.
- (5) ESD rating is based on the human body model, 100 pF discharged through 1.5 kΩ.

## Operating Conditions<sup>(1)</sup>

Temperature Range ( $T_A$ ) <sup>(2)</sup>	LM140	-55°C to +125°C
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- (1) Absolute Maximum Ratings are limits beyond which damage to the device may occur. Operating Conditions are conditions under which the device functions but the specifications might not be ensured. For ensured specifications and test conditions see the Electrical Characteristics.
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## LM140 Electrical Characteristics

55°C ≤ T<sub>J</sub> ≤ +150°C unless otherwise specified<sup>(1)</sup>

Symbol	Output Voltage		5V			12V			15V			Units
	Input Voltage (unless otherwise noted)		10V			19V			23V			
	Parameter	Conditions	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V <sub>O</sub>	Output Voltage	T <sub>J</sub> = 25°C, 5 mA ≤ I <sub>O</sub> ≤ 1A	4.9	5	5.1	11.75	12	12.25	14.7	15	15.3	V
		P <sub>D</sub> ≤ 15W, 5 mA ≤ I <sub>O</sub> ≤ 1A	4.8		5.2	11.5		12.5	14.4		15.6	V
		V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>	(7.5 ≤ V <sub>IN</sub> ≤ 20)			(14.8 ≤ V <sub>IN</sub> ≤ 27)			(17.9 ≤ V <sub>IN</sub> ≤ 30)			V
ΔV <sub>O</sub>	Line Regulation	I <sub>O</sub> = 500 mA	10			18			22			mV
		T <sub>J</sub> = 25°C, ΔV <sub>IN</sub> , -55°C ≤ T <sub>J</sub> ≤ +150°C	(7.5 ≤ V <sub>IN</sub> ≤ 20)			(14.8 ≤ V <sub>IN</sub> ≤ 27)			(17.9 ≤ V <sub>IN</sub> ≤ 30)			V
		T <sub>J</sub> = 25°C	3	10		4	18		4	22	mV	
		ΔV <sub>IN</sub> , -55°C ≤ T <sub>J</sub> ≤ +150°C	(7.5 ≤ V <sub>IN</sub> ≤ 20)			(14.5 ≤ V <sub>IN</sub> ≤ 27)			(17.5 ≤ V <sub>IN</sub> ≤ 30)			V
		T <sub>J</sub> = 25°C	4			9			10			mV
ΔV <sub>O</sub>	Load Regulation	Over Temperature	12			30			30			mV
		ΔV <sub>IN</sub>	(8 ≤ V <sub>IN</sub> ≤ 12)			(16 ≤ V <sub>IN</sub> ≤ 22)			(20 ≤ V <sub>IN</sub> ≤ 26)			V
		T <sub>J</sub> = 25°C	10	25		12	32		12	35	mV	
		5 mA ≤ I <sub>O</sub> ≤ 1.5A		15			19			21	mV	
		Over Temperature, 5 mA ≤ I <sub>O</sub> ≤ 1A	25			60			75			mV
I <sub>Q</sub>	Quiescent Current	T <sub>J</sub> = 25°C	6			6			6			mA
		Over Temperature	6.5			6.5			6.5			mA
ΔI <sub>Q</sub>	Quiescent Current Change	5 mA ≤ I <sub>O</sub> ≤ 1A	0.5			0.5			0.5			mA
		T <sub>J</sub> = 25°C, I <sub>O</sub> = 1A	0.8			0.8			0.8			mA
		V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>	(7.5 ≤ V <sub>IN</sub> ≤ 20)			(14.8 ≤ V <sub>IN</sub> ≤ 27)			(17.9 ≤ V <sub>IN</sub> ≤ 30)			V
		I <sub>O</sub> = 500 mA	0.8			0.8			0.8			mA
V <sub>N</sub>	Output Noise Voltage	V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>	(8 ≤ V <sub>IN</sub> ≤ 25)			(15 ≤ V <sub>IN</sub> ≤ 30)			(17.9 ≤ V <sub>IN</sub> ≤ 30)			V
		T <sub>A</sub> = 25°C, 10 Hz ≤ f ≤ 100 kHz	40			75			90			μV
		T <sub>J</sub> = 25°C, f = 120 Hz, I <sub>O</sub> = 1A	68	80		61	72		60	70		dB
		or f = 120 Hz, I <sub>O</sub> = 500 mA, Over Temperature, V <sub>MIN</sub> ≤ V <sub>IN</sub> ≤ V <sub>MAX</sub>	68			61			60			dB
R <sub>O</sub>	Dropout Voltage	T <sub>J</sub> = 25°C, I <sub>O</sub> = 1A	2.0			2.0			2.0			V
		f = 1 kHz	8			18			19			mΩ
		T <sub>J</sub> = 25°C	2.1			1.5			1.2			A
		T <sub>J</sub> = 25°C	2.4			2.4			2.4			A
		Min, T <sub>J</sub> = 0°C, I <sub>O</sub> = 5 mA	-0.6			-1.5			-1.8			mV/°C
V <sub>IN</sub>	Input Voltage Required to Maintain Line Regulation	T <sub>J</sub> = 25°C	7.5			14.5			17.5			V

(1) All characteristics are measured with a 0.22 μF capacitor from input to ground and a 0.1 μF capacitor from output to ground. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques (t<sub>w</sub> ≤ 10 ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

## Typical Performance Characteristics

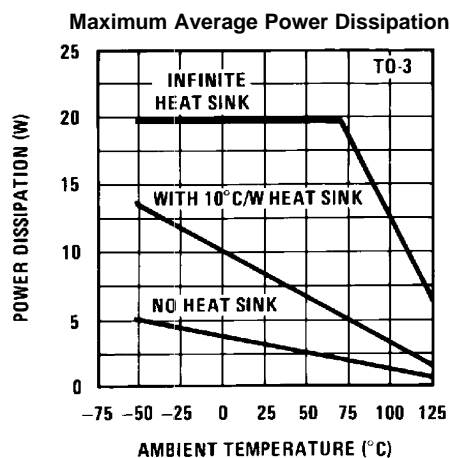


Figure 5.

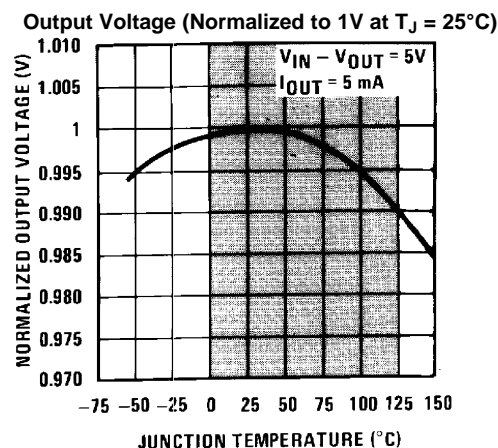


Figure 6.

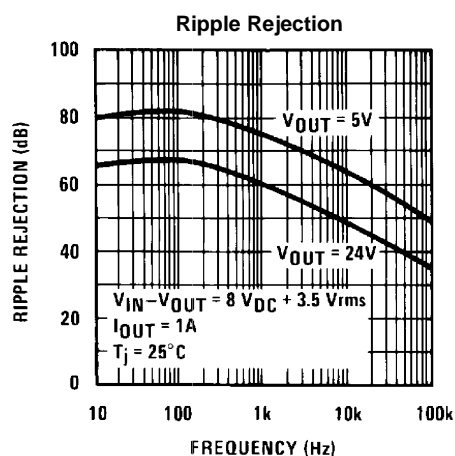


Figure 7.

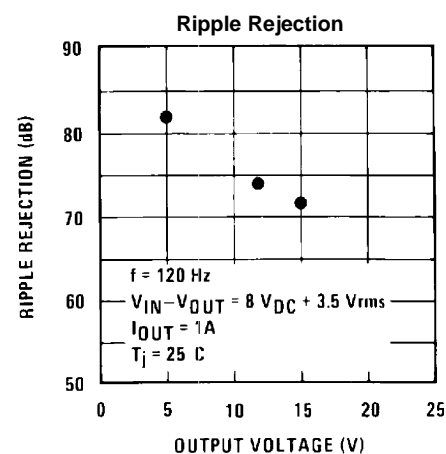


Figure 8.

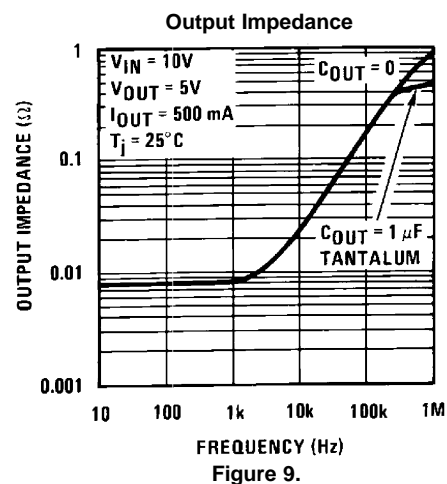


Figure 9.

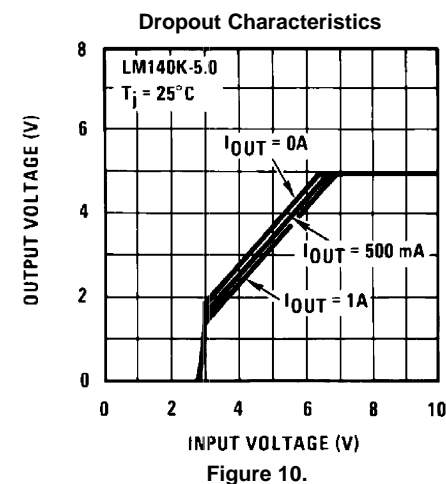


Figure 10.

## Typical Performance Characteristics (continued)

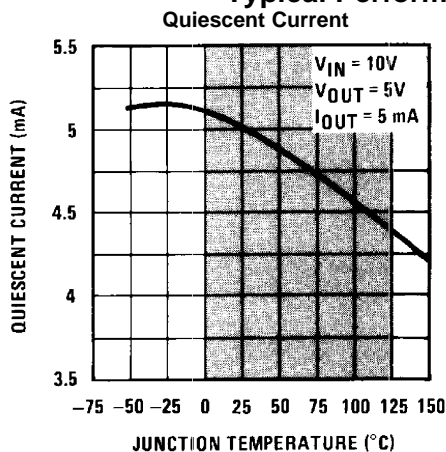


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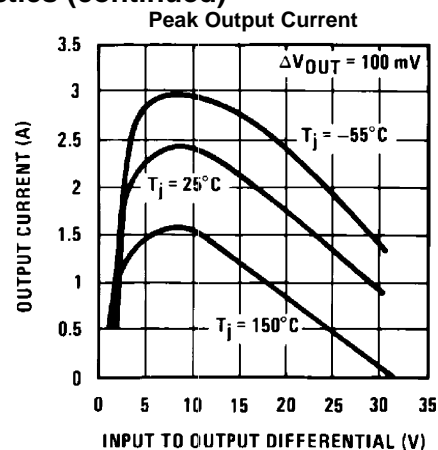


Figure 12.

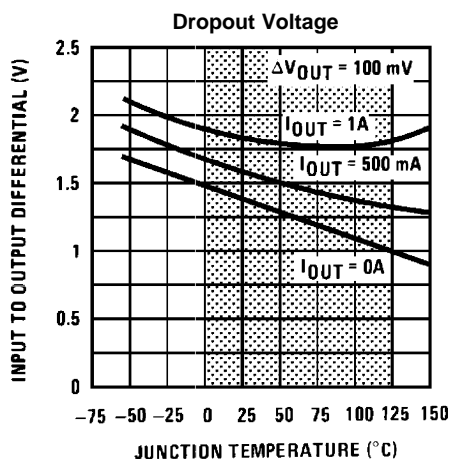


Figure 13.

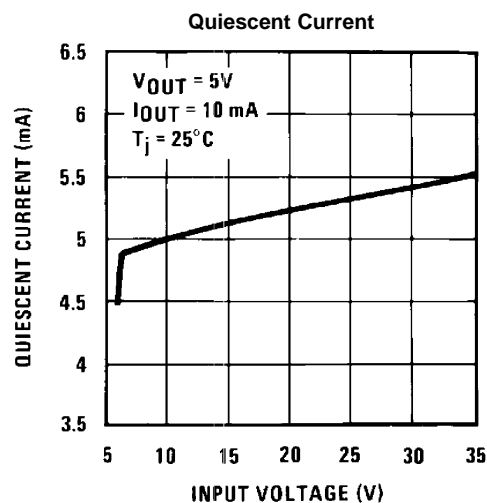


Figure 14.

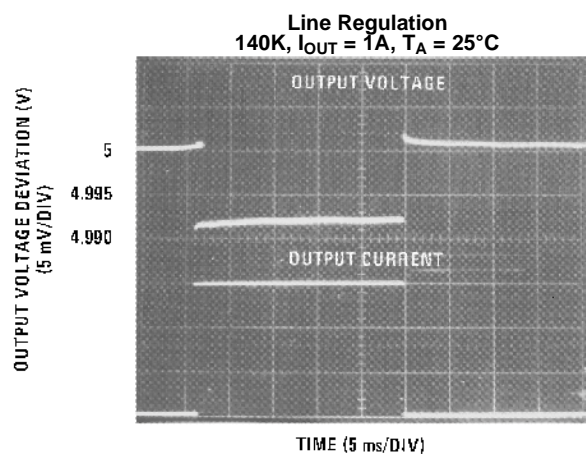


Figure 15.

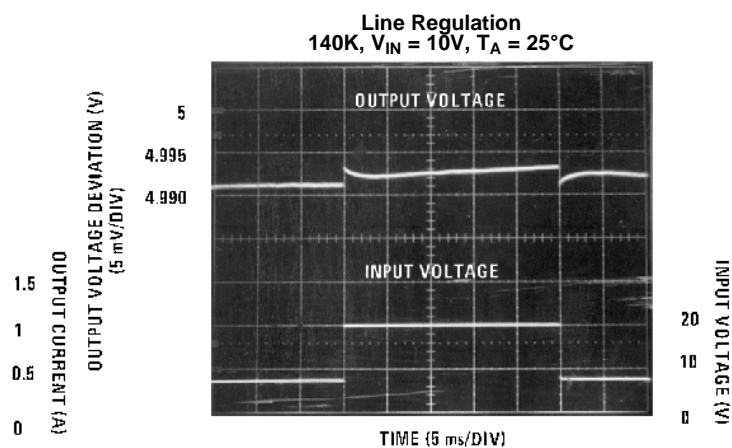
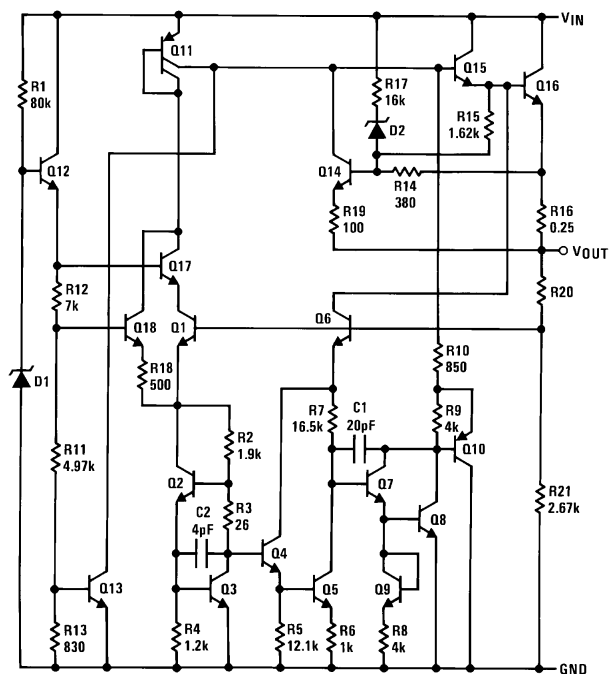


Figure 16.

## Equivalent Schematic



## APPLICATION HINTS

The LM140K is designed with thermal protection, output short-circuit protection and output transistor safe area protection. However, as with *any* IC regulator, it becomes necessary to take precautions to assure that the regulator is not inadvertently damaged. The following describes possible misapplications and methods to prevent damage to the regulator.

### SHORTING THE REGULATOR INPUT

When using large capacitors at the output of these regulators, a protection diode connected input to output (Figure 17) may be required if the input is shorted to ground. Without the protection diode, an input short will cause the input to rapidly approach ground potential, while the output remains near the initial  $V_{OUT}$  because of the stored charge in the large output capacitor. The capacitor will then discharge through a large internal input to output diode and parasitic transistors. If the energy released by the capacitor is large enough, this diode, low current metal and the regulator will be destroyed. The fast diode in Figure 17 will shunt most of the capacitors discharge current around the regulator. Generally no protection diode is required for values of output capacitance  $\leq 10 \mu\text{F}$ .

### RAISING THE OUTPUT VOLTAGE ABOVE THE INPUT VOLTAGE

Since the output of the device does not sink current, forcing the output high can cause damage to internal low current paths in a manner similar to that just described in the “Shorting the Regulator Input” section.

### REGULATOR FLOATING GROUND (Figure 18)

When the ground pin alone becomes disconnected, the output approaches the unregulated input, causing possible damage to other circuits connected to  $V_{OUT}$ . If ground is reconnected with power “ON”, damage may also occur to the regulator. This fault is most likely to occur when plugging in regulators or modules with on card regulators into powered up sockets. Power should be turned off first, thermal limit ceases operating, or ground should be connected first if power must be left on.

### TRANSIENT VOLTAGES

If transients exceed the maximum rated input voltage of the device, or reach more than 0.8V below ground and have sufficient energy, they will damage the regulator. The solution is to use a large input capacitor, a series input breakdown diode, a choke, a transient suppressor or a combination of these.

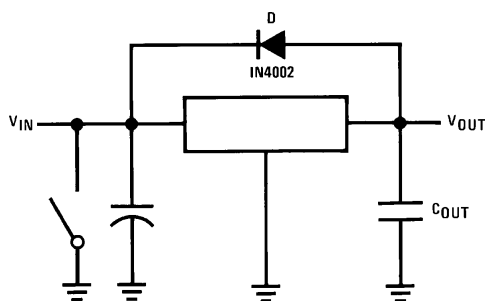


Figure 17. Input Short

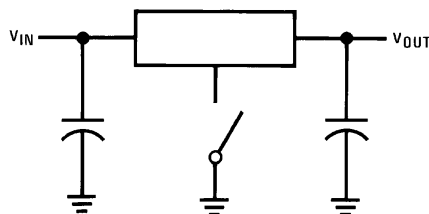
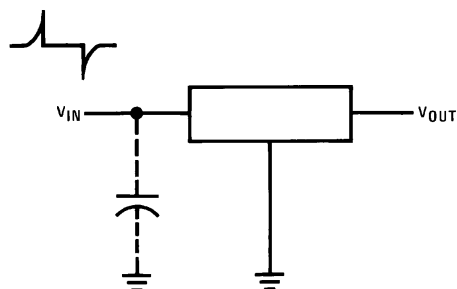


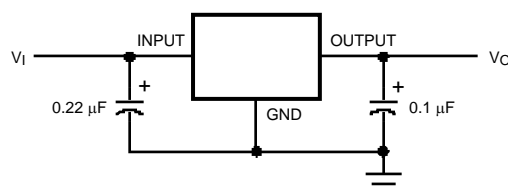
Figure 18. Regulator Floating Ground

**Figure 19. Transients**

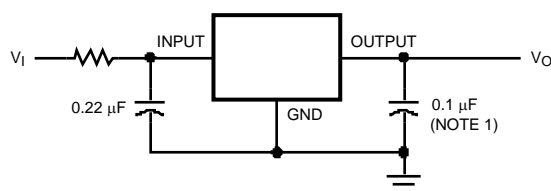
When a value for  $\theta_{(H-A)}$  is found using the equation shown, a heatsink must be selected that has a value that is less than or equal to this number.

$\theta_{(H-A)}$  is specified numerically by the heatsink manufacturer in this catalog, or shown in a curve that plots temperature rise vs power dissipation for the heatsink.

## Typical Applications



Bypass capacitors are recommended for optimum stability and transient response, and should be located as close as possible to the regulator.

**Figure 20. Fixed Output Regulator**



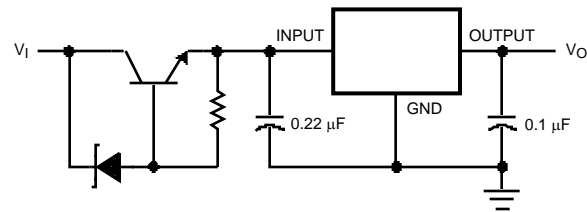
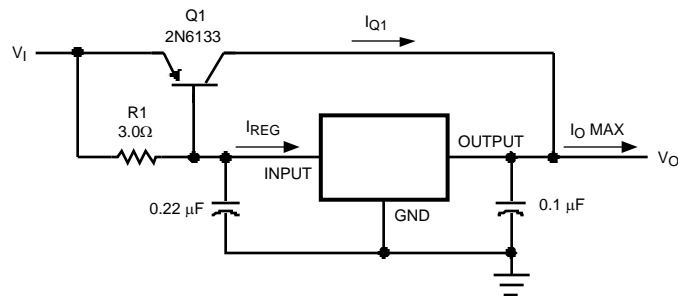


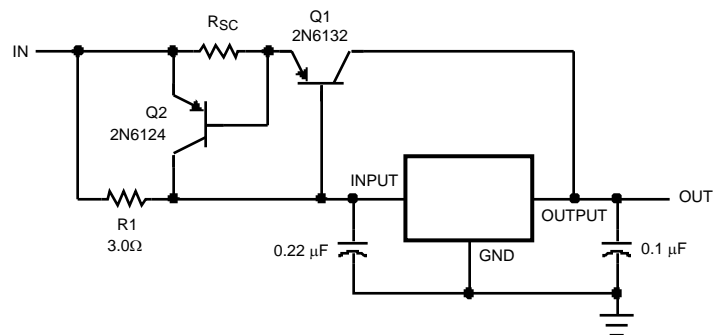
Figure 21. High Input Voltage Circuits



$$\beta(Q1) \geq \frac{I_{O \text{ Max}}}{I_{\text{REG Max}}}$$

$$R1 = \frac{0.9}{I_{\text{REG}}} = \frac{\beta(Q1) V_{\text{BE}}(Q1)}{I_{\text{REG Max}} (\beta + 1) - I_{O \text{ Max}}}$$

Figure 22. High Current Voltage Regulator



$$R_{\text{SC}} = \frac{0.8}{I_{\text{SC}}}$$

$$R1 = \frac{\beta V_{\text{BE}}(Q1)}{I_{\text{REG Max}} (\beta + 1) - I_{O \text{ Max}}}$$

Figure 23. High Output Current, Short Circuit Protected

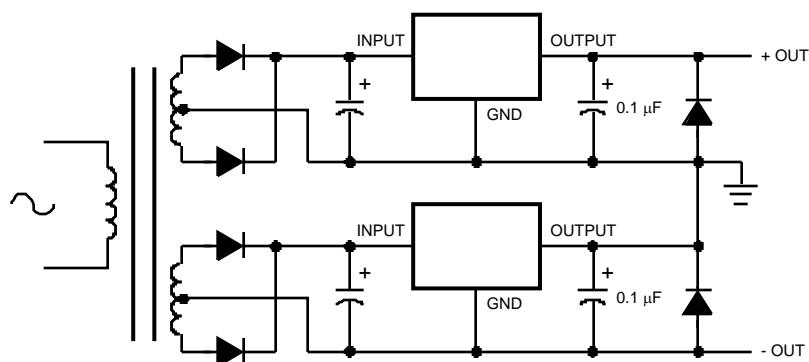


Figure 24. Positive and Negative Regulator

## PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM140K-12	ACTIVE	TO-3	NDS	2	50	TBD	Call TI	Call TI	-55 to 125	LM140K 12P+	<a href="#">Samples</a>
LM140K-12/NOPB	ACTIVE	TO-3	NDS	2	50	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-55 to 125	LM140K 12P+	<a href="#">Samples</a>
LM140K-15	ACTIVE	TO-3	NDS	2	50	TBD	Call TI	Call TI	-55 to 125	LM140K 15P+	<a href="#">Samples</a>
LM140K-15/NOPB	ACTIVE	TO-3	NDS	2	50	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-55 to 125	LM140K 15P+	<a href="#">Samples</a>
LM140K-5.0	ACTIVE	TO-3	NDS	2	50	TBD	Call TI	Call TI	-55 to 125	LM140K 5.0P+	<a href="#">Samples</a>
LM140K-5.0/NOPB	ACTIVE	TO-3	NDS	2	50	Green (RoHS & no Sb/Br)	Call TI	Level-1-NA-UNLIM	-55 to 125	LM140K 5.0P+	<a href="#">Samples</a>

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

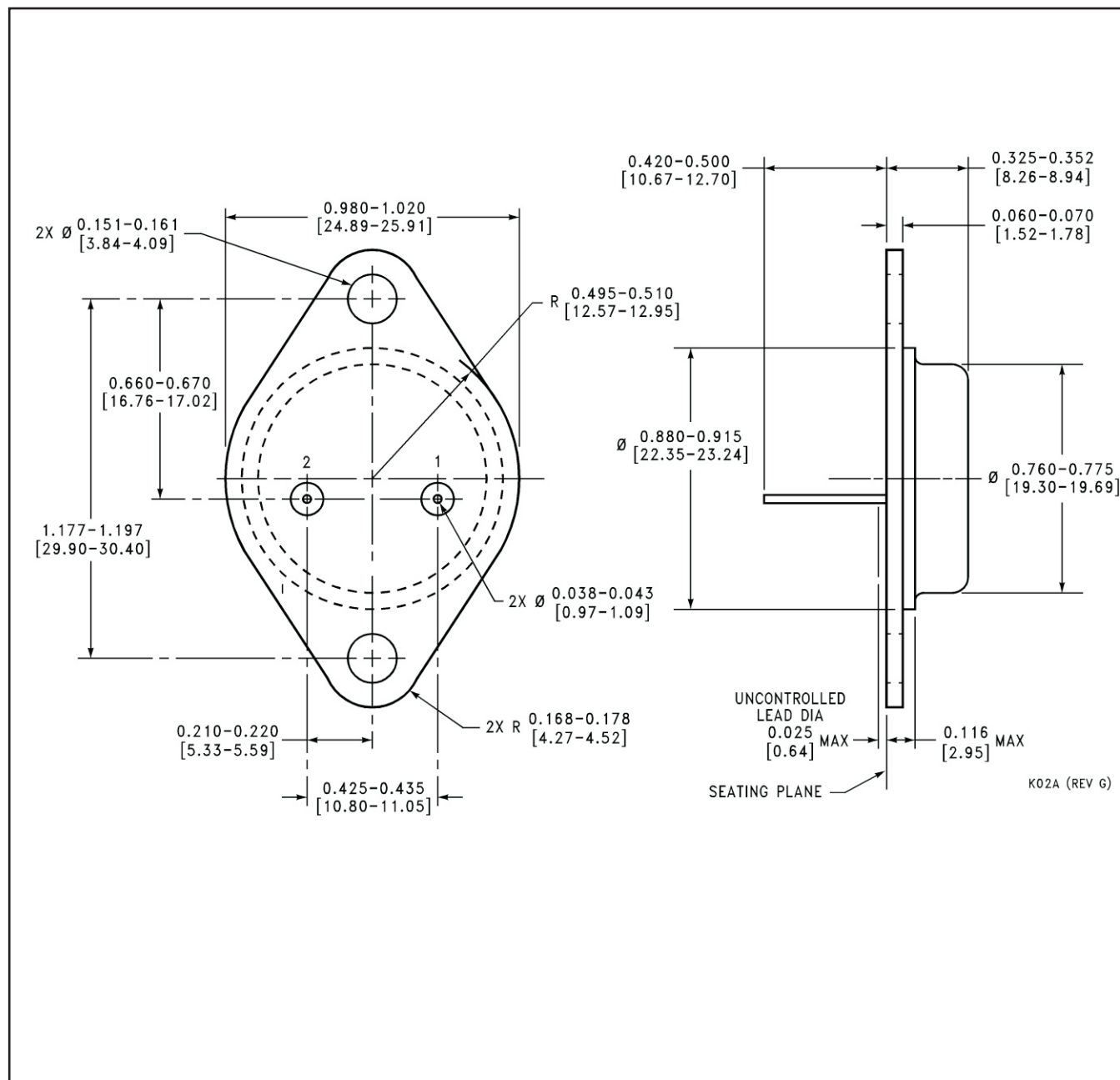
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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